BEFORE
THE OHIO POWER SITING BOARD

In the Matter of the Application of Republic Wind, LLC for a Certificate to Site Wind Powered Electric Generating Facilities in Seneca and Sandusky Counties, Ohio	))))	Case No. 17-2295-EL-BGN

DIRECT TESTIMONY OF IRA SASOWSKY ON BEHALF OF THE LOCAL RESIDENT INTERVENORS

Q.1. Please state your name and work address.

A.1. Ira Daniel Sasowsky. 379 Bittersweet Rd., Akron, OH 44333

Q.2. What is your educational background?

A.2. I have a Bachelor of Science (BS) degree in geology from the University of Delaware. I hold masters (M.S.) and doctoral (Ph.D.) degrees in geology from The Pennsylvania State University. Beyond that I have attended many continuing education functions such as general or specialty conferences in my professional field.

Q.3. What is your occupation?

A.3. I am a geoscientist, and a principal in Sasowsky Earth Science Consultants, Ltd., also referred to as SESC, a professional services company providing geologic, hydrologic, and soils consulting. I serve also as Professor of Geosciences at the University of Akron (Ohio).

Q.4. Please provide an overview of your occupational experience.

A.4. A full curriculum vita is given in Exhibit A. I am a registered Professional Geologist in Pennsylvania and Tennessee; Ohio does not offer registration for geologists. My

dissertation and thesis research topics were both focused on karst areas in the eastern United States.

I have provided advice to clients including Fortune 100 companies, utilities, homeowners, citizens groups, insurance firms, and legal firms. Much of that work has been in areas underlain by carbonate rocks. Representative projects in carbonate rock settings include: evaluation of quarry water inflows, causes of sinkhole flooding, delineation of groundwater protection areas, hydrology and geochemistry of groundwater contamination in carbonate aquifers, and causes of ground subsidence. I have also received funding through Ohio EPA and U.S. Dept. of Agriculture in support of research to advance understanding of karst areas.

Q.5. What professional honors have you received?

A.5. Professional organizations have recognized my work with the following honors: Fellow and Hydrogeology Division Distinguished Service Award of the Geological Society of America; Fellow, Science Award, Certificate of Merit, and Ralph Stone Research Award of the National Speleological Society; Jeff Jefferson Research Award of the British Cave Research Association; and the Distinguished Service Award of the Association of Ohio Pedologists. Pedology is the study of soil science.

Q.6. On whose behalf are you offering testimony in this case?

A.6. I am offering testimony on behalf of Intervenors Joseph & Diane Anderson, Denise Bell, Aaron & Carrie Boes, Richard & Linda Bollenbacher, Rob & Mary Chappell, Thomas & Kathleen Fries, Leslie & Dennis Hackenburg, Jeffrey & DeeAnne Hamilton, Allen & Mary Hassellbach, Duane & Deb Hay, Ethan & Crystal Hoepf, Gary & Dawn Hoepf, Jason & Michelle Hoepf, Taylor Hoepf, David P. Hoover, Jeffrey A. Hoover, Kenneth &

Debra Hossler, Greg & Laura Jess, Mike & Tiffany Kessler, Leonard & Beverly Kubitz, Gary & Michelle Miller, Steven & Kelley Miller, Kim Mitchell, Charles & Linda Morsher, Patricia Motry, Steven & Linda Mulligan, Doug & Jennifer Myers, Linda Niederkohr, Kevin & Jennifer Oney, Nicholas & Michelle Reiter, Tom & Lori Scheele, Elaine Schultz, James & Victoria Seliga, Eugene & JoAnn Smith, James & Elaine Steinmetz, Herman & Patricia Studer, Christine Vogt, Mark Weber & Cindra Riley, Charles & Rhonda Weyer, Ann Wright, and Chris & Danielle Zeman (together, the "Local Residents").

Q.7. What is the purpose of your testimony?

A.7. The purpose of my testimony is to inform the Ohio Power Siting Board about the geological and hydrogeological risks that are associated with the installation of the wind project for which Republic Wind, LLC is requesting a certificate from the Board. My testimony also identifies the deficiencies in geological and hydrogeological information contained in Republic Wind's Application for the certificate.

Q.8. What documents did you consult in preparing for your testimony?

A.8. I examined all materials posted on the case page of the OPSB website, including the Staff Report and Supplementary Staff Report. I made a more detailed examination of those documents that specifically pertained to geology, hydrology, and karst. I also reviewed several other pertinent documents regarding windfarms/karst, which I will discuss later in my testimony.

Q.9. What is karst?

A.9. The definition of karst from the American Geological Institute Glossary is: "A type of topography that is formed on limestone, gypsum, and other rocks, primarily by

dissolution, and that is characterized by sinkholes, caves, and underground drainage." Simply put, karst regions are those, usually underlain by limestone or dolostone, types of carbonate-rich bedrock, where dissolution of the rocks has produced a characteristic set of features and behaviors. For an illustration, see Exhibit B. Karst forms on, and in, these particular rocks because they are easier to dissolve than many other rocks such as sandstones, shale, and granite. The primary features of karst regions are sinkholes and caves, along with disappearing streams. These features originate by the movement of naturally acidic water through the bedrock, which wears away the rock. This can create relatively large, and laterally extensive, routes for water to move through the rock. When these pathways are large enough for humans to traverse, we call them caves. Some of these can reach extreme size and length. Mammoth Cave, Kentucky, for example is 405 miles long; the longest cave in the world. There are many examples of cave rooms having volume greater than 1 million cubic yards. However, there also exist many smaller and shorter pathways which are not humanly traversable, but which do allow for the very rapid and focused movement of water. This leads to significant challenges for the safe development of any infrastructure in these settings, even in the absence of large sized openings.

To understand the basic process by which karst features form, it is useful to consider them in the context of the water cycle. Water on earth follows a complex trajectory through what we call the hydrosphere. Briefly stated, water that evaporates from ocean basins and other areas is carried across the continents where it may fall from the atmosphere as precipitation, rain, snow, etc. When that precipitation lands on the earth it may run off directly across the surface into streams, fairly quickly making its way

to larger rivers, and then back to the ocean. An alternative pathway is for the rainwater to infiltrate, or soak into, the soil. When this occurs, the water can make its way downward to join with the groundwater flow system. This is called groundwater recharge. Along this pathway, which is typically quite slow, water is driven by hydraulic gradients in downward, lateral, or even upward directions. It eventually makes its way back to the surface, emerging as springs or seeps, or as base flow in streams. This process is illustrated in Exhibit C. In most non-carbonate rock settings, the pathway is as shown in the upper cross section. But, in those cases where the bedrock is a carbonate material, such as limestone or dolomite, the water traveling along the path can act to dissolve away the rock creating larger pathways (lower part of Exhibit C). This process is known as karstification. It is an ongoing process that has many phases. Although the process is slow on the human timeframe, the longer periods associated with geologic history allow for the development of extensive pathways and large features. In some cases the openings within the bedrock can become in filled with loose geological materials, which may be called soil, or regolith. This material may partially or fully block water movement through the bedrock openings, at least temporarily.

Q.10. What experience do you have with karst?

A.10. Over my career I have specialized in research on karst (cave and sinkhole) development. I have been examining and working in karst terrains for about 40 years. This work has included academic research, as well as consulting for technical concerns. The technical subfields within which I have worked in karst settings include geomorphology, hydrogeology, geochemistry, and environmental chemistry.

This has included field experience in karst areas of 25+ U.S. states, South America, the Caribbean, and Europe. I have observed karst features in natural settings, in quarries, in road cuts, etc. I have entered and examined over 500 caves throughout the world. In the state of Ohio I have directed several research projects in various karst areas. I have edited 11 scientific books on karst, been an author of numerous technical reports, and published close to 50 scientific articles which have appeared in journals such as: Earth & Planetary Science Letters, Environmental Geology, Geology, Geomorphology, Journal of Cave & Karst Studies, Journal of Hydrology, Quaternary Research, Science, Water Research, and Water Resources Research. I have presented the results of scientific work and published more than 100 abstracts at national and international meetings, as well as giving invited lectures at universities in North America and Europe. My knowledge has been shared with hundreds of students, colleagues, professionals, and the public through classes, field trips, sessions, and conferences. During my 15-year tenure as the earth sciences editor of the Journal of Cave and Karst Studies, I oversaw the publication of cutting-edge research in this discipline.

Q.11. Have you conducted any karst studies on behalf of any government agencies?

A.11. Yes. I have, along with collaborators, conducted two major projects examining the conditions, processes, and features of karst areas. The first was a two-year project, funded by the US EPA through the Ohio EPA 319 grant program. The general purpose of this project was to improve water quality in an area of Ohio by evaluating the utility of a unified source water protection plan for the Bellevue– Castalia Karst Plain. The second project was funded by the US Department of Agriculture, and in that work we examined

methods for the handling of storm water in karst terrains, and made recommendations about best practices. Both of these projects resulted in technical reports.

Q.12. What experience do you have with karst within or near the Project Area?

A.12. I made my first visits to this area about 20 years ago with colleagues from the geology department at Oberlin College. Since that time I have made many other visits to examine the karst features, and conduct research. The first government agency project mentioned in the question above was located in and around the Bellevue-Castalia Karst Plain, a physiographic sub-province in Ohio, which significantly overlaps the proposed Republic Wind project area. I directed that project, with a number of collaborators assisting in the work. The undertaking involved an extensive desktop study which developed a lengthy annotated bibliography for the area. Following that, our investigations included field mapping, dye tracing, well video, statistical analysis of drilling records, geophysical investigations, and geochemical modeling. These are explained in our report, (Sasowsky, I. D., and others, 2005, Results of Investigation: Bellevue-Castalia Karst Plain Groundwater Planning Project, 516 p.)

One important conclusion of that study was the recognition that certain areas that did not appear to be karst, because they did not have known sinkholes or caves, actually had karst behavior present. By this I particularly mean openings in the bedrock that allow fast movement of water and sediment.

Q.13. How prevalent is karst in the vicinity of the Project Area?

A.13. Karst is extremely prevalent in the vicinity of the project area. The project area significantly overlaps the Bellevue-Castalia Karst Plain, one of the four main karst districts in Ohio. See Exhibit D. In addition, a PDF map prepared by the Division of

Geological Survey indicates that this area is on the eastern edge of a very broad region which is potentially karst, and also has many identified karst features. Detailed publications prepared by the Division of Geological Survey, authored by Douglas Aden and others, have field verified and precisely mapped these features. Some of these reports are referenced or reproduced in the Application by Republic Wind. Additionally, Application Exhibit F is a report prepared by the consulting firm Hull, titled Groundwater Hydrogeological and Geotechnical Desktop Document Review Summary Report for the Proposed Republic Wind Project Located in Seneca and Sandusky Counties; ACX 002.300.0011 Figure 4 in that report, which I include here as my Exhibit E, shows the outline of the Republic Wind project area, along with "known karst" points, and shaded areas which are labelled "probable karst". The method in which "probable karst" was delineated is not explained in the report, but appears to be some sort of circular buffer around features. When this figure is compared to the karst interactive map viewer available online at the ODNR Division of Geological Survey website, it appears that the points on figure 4 match what are called "Karst Points - Field Verified" from that database. What is absent from figure 4 are other points which are classified as "Karst Suspect - Field Visited" and "Karst Suspect - Not Visited". There are many such points in the study area. Furthermore most, if not all, of the Republic Wind Project area is underlain by Silurian and Devonian age carbonate bedrock overlain by more or less than 20 feet of glacial drift and/or alluvium. This is shown by activating the layer titled "Karst Geology of Ohio" on the ODNR karst interactive map.

In summary, karst appears to be pervasive throughout the project area. It is therefore imperative that steps be taken to characterize the conditions, in order to avoid environmental impacts.

Q.14. Can the underground presence of karst always be detected by examining geological features that are visible on the land surface?

A.14. No. Such a determination cannot be definitively made in many cases, and we showed this is true in the Bellevue-Castalia Karst Plain with the research project that I mentioned above. Throughout this region the bedrock is covered by varying thicknesses of loose sedimentary material; sand, silt, and so forth. Most of these materials were deposited during and at the end of the last ice age, and are collectively called ”glacial drift”. In places where the drift is thick, sinkholes and other superficial karst features may be obscured, or hidden, since they are buried. Several researchers have noted a correlation between thin layers of drift and the presence of visible karst surface features. However, even in places where the bed rock cover is thin, the absence of superficial karst features does not mean that karst is not present. There can be, and frequently are, caves and smaller groundwater conduits present in carbonate bedrock with very little surface expression of dissolution features. Consequently, the old saying “the absence of evidence is not the evidence of absence” holds particularly true. Generally, to be sufficiently protective, when there is carbonate bedrock present, one should assume that it is karstified unless it can be demonstrated otherwise.

Even areas that we think are stable can develop problems. Sometimes these have terrible consequences. For example, in March 2013 in Seffner, Florida a collapse sinkhole developed underneath the bedroom of a house and killed a man. The home is

believed to have been built in the mid 1970s and so had remained stable 40 or more years before this unexpected collapse occurred.

Exhibit F shows 2 mechanisms by which sinkholes form, and how they make a connection between the land surface and the subsurface.

Q.15. How do cavities, conduits and openings form in karst?

A.15. As mentioned above, the general process is that water circulates through carbonate bedrock such as limestone or dolomite, and along its pathway it dissolves the bedrock away creating openings. The dissolving power of the water comes primarily from small amounts of carbon dioxide that are in it. This creates a weak acid, carbonic acid, which greatly accelerates the dissolution of bedrock. The general equations describing this process are H_2O (l) + CO_2 (g) >> H_2CO_3 (aq); H_2CO_3 (aq) >> HCO_3^- (aq) + H^+ (aq); H^+ (aq) + $CaCO_3$ (s) >> Ca2+ (aq)+ HCO_3^- (aq); where $CaCO_3$ is calcite, the mineral comprising limestone.

Sometimes these openings then become filled in, or partially filled in, with loose geological material. This can give the impression of stability, but these materials can be mobilized by infiltrating water, particularly with changes in drainage, and create damaging collapses such as the one mentioned from Florida.

Q.16. Has this dissolution of rock finished, or is it an ongoing process?

A.16. The dissolution of rock is an ongoing natural process. As long as water is moving through the bedrock, some dissolution will likely continue to occur.

Q.17. What information have you learned about karst in the Project Area that is useful for determining whether wind turbines can be constructed there without harming the public and the environment?

A.17. From our previous studies, we have developed a broad understanding of the processes that are at work in this region. This serves as a framework for developing a more nuanced understanding of the potential specific effects of the proposed Republic Wind project. It does not, however, remove the need for site-specific studies.

Some of the pertinent factors are these. Karstification in this area is actually occurring via two processes. There is evidence of the typical top-down (epigene) karstification that occurs when water moves down into the ground. This is seen, for example in sinkholes and swallets (sinking stream points) in much of the region. However, there is another very significant process at work. Relatively deep groundwater circulation, moving in a generally north direction, is dissolving certain beds in the underlying Salina Group. This is causing upwards collapses which in some cases reach the land surface, creating very large sinkholes in the overlying carbonate rocks. Evidence for this process is found through examining the morphology of the sinkholes, their position in the landscape, and also through geochemical modeling of spring water discharges at regional springs to the north of the Republic Wind project area. This situation is discussed in detail in the report from our Ohio EPA project mentioned earlier, as well as in a conference paper that we published in 2003. This paper is Sasowsky, I. D., Dinsmore, M. A., Salvati, R., Bixby, R., Raymond, H., and Mazzeo, P., 2003, "Subtle but significant karst on the glaciated Bellevue-Castalia Karst Plain, Ohio, USA," in Beck, B. F., ed., Sinkholes and the engineering and environmental impacts of karst (Geotechnical Publication No. 122): Reston, Virginia, American Society of Civil Engineers, p. 95-109.

Furthermore, we verified that the apparent absence, or limited occurrence, of surficial karst features such as sinkholes, does not indicate that karst is absent. For

example, in Bloom Township, just south of the Republic Wind project area, we found three indications of substantial karst groundwater flow even though there are few sinkholes in the area. The first piece of evidence was an apparently natural collapse that occurred on one of the local streams, Honey Creek, that diverted streamflow into the subsurface for substantial period of time. The second piece of evidence was a sinkhole just south of the Hanson Aggregates Bloomville Quarry, which was reported to take in copious amounts of storm water runoff without ever backflooding. The third line of evidence was a dye trace that we conducted into a small opening in a farmer's field, between the quarry and Honey Creek. Fifteen pounds of fluorescein dye powder followed with 145,000 gallons of water were used, yet no dye was recovered at any of the detection points. This confirms rapid karst flow behavior, even in portions of this region that are not traditionally considered to be karst.

Q.18. Based on your review of the pertinent records, do you have any concerns with the wind project for which Republic Wind has requested a certificate?

A.18. Yes.

Q.19. Please provide the Board with a short overview of your concerns.

A.19. A substantial portion of the project area is in karst terrain. Experience at many locales has shown that human activities in these sorts of areas require special attention in order to avoid or minimize the following three issues: 1) land failure or subsidence (sinkholes, collapses), 2) disruption of water supplies, 3) contamination of water supplies, and 4) flooding. These may occur during the construction or operations phases. The Application gives only cursory attention to these potential concerns.

Q.20. What are the risks of land failure or subsidence (sinkholes, collapses) if wind turbines are constructed in the area?

A.20. There are number of issues with either slow land subsidence, or rapid collapse. Each instance represents the lowering of the earth's land surface downward. This occurs either because there was an existing opening in the underlying material, or a new opening has been formed. Subsidence and collapses can be brought about in several ways. The first way is by excessive loading. This occurs when additional weight is put on the land surface, and the underlying material is either compressed, in the case of sedimentary material, or fails, which can also be the case with sedimentary material, or within bedrock overlying cavities. In order to avoid this problem, the subsurface must be thoroughly characterized by boring or other methods. A second way that subsidence or collapse can occur is by the generation of new voids in the subsurface. This typically occurs by the erosion of sedimentary fill from existing karst cavities. As mentioned earlier in this testimony, it is very common for a bedrock karst to be filled or partially filled in with loose sediments on top of it. If surface drainage is changed, this can direct water down into some of these conduits which has the effect of eroding, or wearing away, the sediments that are present. Once that occurs, additional water flow maybe induced, and failure of the surface can occur due to removal of the material. The time frame for collapse such as this to be induced may vary from days to decades. You can see in Exhibit G that this area is lacking in surface streams. This means it can be very challenging to safely deal with stormwater.

Q.21. What are the risks of groundwater contamination if wind turbines are constructed in the Project Area?

A.21. Groundwater contamination happens in karst areas because there may be open, and quick pathways that connect surface water to the groundwater. This is different than in non-karst areas, where slow movement of water through tiny openings usually filters and cleans surface water before it can reach the groundwater. Risks of groundwater contamination primarily come from making changes to the surface that would facilitate rapid movement of surface water into the ground.

This is a well-known problem in the Bellevue Castalia Karst Plain area. For example, there was severe and widespread damage to drinking water supplies in the Bellevue area (just north of the Republic Wind project) from the early 1900s through the early 1960s. This occurred due to contaminated water making its way in to wells and sinkholes; this is spelled out in a report titled "Contamination of underground water in the Bellevue area" that was prepared for the Ohio Water Commission by the Groundwater Geology Section of the Ohio Division of Water in June 1961. Changes in waste disposal practices relieved some of these. .

When changes are made to the land surface, from activities like constructing turbines, water from fields, ditches, and constructed areas which may be contaminated may be directed into sinkholes or other openings which provide a direct connection to the aquifer. This water is generally of lesser quality than existing groundwater, and can be unhealthy for human consumption. This is why it is important to have a specific understanding of the movement of water at each site. This can be accomplished in a number of ways, but almost always requires more than simple visual inspection. Dye tracing is a common approach to identifying flow directions and recharge zones. This has been carried out in some parts of Ohio by ODNR and other entities. A report was

prepared in March 1994 titled "Impact of best management practices on surface run off and groundwater quality in a solution limestone area, Thompson Township, Seneca County, Ohio". It was prepared by number of researchers from the ODNR Division of Water, the Seneca County Soil and Water Conservation District, and the University of Toledo. This area appears to overlap in part the Republic Wind project area. This study could provide insight to more safely construct the wind project, but it does not appear that this document was used in preparing the Application.

It is acknowledged in Exhibit F of the Application, the Hull report, that there are several source water protection areas overlapped by the Republic Wind project. The associated map is presented here as Exhibit H. The largest of these areas is a groundwater source water protection area for Capital Aluminum and Glass. Twenty-one of the proposed turbines are located within this. The area is listed as high vulnerability. There are also two surface water protection areas, one for the city of Clyde and one for the city of Fremont which encompass Beaver Creek, and a portion of the Sandusky River, respectively. These are reported to contain proposed locations for 24 and 13 turbines, respectively. In all, of these cases, it is important to make sure that turbine construction does not contaminate a water supply.

In these areas, as well as any place where a domestic or agricultural well might be impacted, a high level of care should be taken to protect the resource.

Q.22. What are the risks to the availability of water supplies if wind turbines are constructed in the Project Area?

A.22. This is an important consideration, as the viability of a water supply includes not only its quality, as mentioned above, but also its quantity. The availability of suitable water for

drinking, agricultural, and other purposes, is critical in a rural area such as this. The majority of residences are supplied by individual private wells, which make use of groundwater from underneath their property. If such supply were to be lost, it would be devastating for the residents.

For this reason, it is necessary to understand for each well where the water comes from. This includes identifying the aquifer, as well as the recharge zone for the well which is extracting the water. This could then guide design and construction to avoid disruption of recharge to the well. Paving, the installation of concrete bases, and grouting, for example, are all practices which can tend to limit recharge to an underlying aquifer, and need to be avoided or managed. Without this, the proposed project could disrupt residential or other water supplies.

Q.23. What are the risks of flooding if the Project is constructed?

A.23. Sinkholes can flood when they get plugged up with sediment. This plugging can result from erosion at the surface, and changes to surface drainage due to construction of structures such as turbines. However, what may be more hazardous is that underground water can also flood upwards from the sinkholes under certain conditions. In this case the sinkholes act as groundwater discharge points, instead of groundwater recharge points. It is well documented in this region that occasionally intense rain falls result in severe flooding from upward movement of groundwater. This last occurred in 2008, and was explained in a report and detailed map prepared by the Ohio Department of Natural Resources that was published in 2009. These sorts of upward movement of water could be extremely disruptive of foundation stability.

Q.24. Did Republic Wind conduct an adequate investigation to evaluate the risks you have described?

A.24. The information in the Application does not disclose the full possible impact of the Project, nor is the Project designed to minimize adverse environmental impact. The overarching concern is that scant attention has been paid to the protection of water resources, or the special concerns of infrastructure development on karst. In the Application's narrative, page 53, it is stated that impacts are expected to be minor, based upon the relatively small footprint compared to total area. However, this does not preclude significant impacts for a given landowner. The Application is a 217-page document, with numerous appendices. The word karst is used only 11 times within the body of the Application, which is surprising because this landscape characteristic is dominant, and would be expected to present challenges.

Appendix F of the Application is the Hull report, titled Groundwater Hydrogeological and Geotechnical Desktop Document Review Summary Report. In this report there is a brief discussion of karst, and the map which I previously mentioned, my Exhibit E. The emphasis of this report is really construction stability for the turbines. For example in the summary it is stated "…it does not appear that the construction of the proposed wind turbines will have a significant impact on the local geology and slash for hydrogeology of the Project Boundary." But scant consideration is given to karst issues. Appendix E of that document is a generalized geotechnical exploration workplan. But, again, this really just addresses stability of the construction, not impacts to the environment.

Q.25. What additional investigation is necessary to determine whether wind turbines can be constructed in the Project Area without harming the public or the environment?

A.25. The entire area needs to be better understood with regard to understanding the movement of water and the aquifers that are present. Beyond that, each proposed site should be characterized with regard to the movement of surface and groundwater. This information should then be used to answer the following questions and others: What impact to aquifer recharge will occur due to the proposed construction? What impact to groundwater quality will occur due to the proposed construction? What changes to surface and subsurface water drainage will occur, and could these promote land subsidence or collapse due to accelerated movement of loose material within the karstified bedrock? The plan for the investigation should be made with the input of a qualified professional who has experience in karst terrains. Likewise, the work on the ground should make use of personnel with experience in karst settings.

Q.26. Does Republic Wind's Application provide sufficient information to determine whether the turbines will cause karst collapse, groundwater contamination, or disruption of groundwater supply?

A.26. No. In order for any construction to be carried out with minimal environmental impact in a karst area, a detailed background study should be conducted, in which potential impacts to water quantity, water quality, and subsidence risks are thoroughly evaluated. This can only be accomplished with an understanding of such basic questions as: What aquifers are present? What are the groundwater flow directions? What are the recharge and discharge areas? Who are the water users? What is the capture zone for their extraction? If these things are not understood, it is difficult, if not impossible, to predict what

environmental impacts may occur due to construction. Furthermore, baseline data, pre-construction, should be obtained for water supplies, so that any impacts can be evaluated.

The Application does not demonstrate minimal adverse environmental impact. A full understanding of the nature of the karst environment is not presented, or planned. Since the Application does not supply sufficient information to describe the nature of environment, it is impossible to clearly evaluate impact. This is especially true with regard to groundwater impacts.

Q.27. What additional information must be collected before deciding whether a turbine should be constructed at a site?

A.27. If the construction cannot be accomplished without presenting risk to water quality, water quantity, land subsidence, or land collapse, then it should not move forward. In order to evaluate that risk, each location should be characterized at a minimum using appropriate investigative techniques for the following: 1) aquifers present, and the flow directions within them, 2) cataloging of individual karst features such as caves or sinkholes, 3) ground support characteristics, 4) storm water flow and recharge pathways and amounts, and 5) capture zones for any water extraction points such as residential wells

Q.28. What conditions, if discovered by this additional investigation, should preclude the construction of a wind turbine at a specific site?

A.28. It is not possible to make a comprehensive list of conditions that would preclude such construction given the limited information provided by the Application. It seems to make sense that the applicant, instead, should demonstrate with the support of data that the work it is proposing will not damage the environment.

Q.29. Is it possible to just refrain from building directly on sinkholes, in order to avoid any problems?

A.29. No. Unfortunately, that is not the case. It is not possible to avoid karst related problems by simply avoiding construction on known karst features, though that practice certainly is advisable. Karst does not occur as isolated features, but rather pervades the entire landscape. Avoiding construction on a specific karst landform such as a sinkhole is good, but this does not remove concerns for environmental impacts. Recall that karst is a characteristic of this region. When rainwater falls on the surface, or when snow melts, the water needs to go somewhere. This usually means that it's going to go down into the ground, through one pathway or another. Karst risks exist even where sinkholes are not found. A significant portion of the proposed Republic Windfarm lies on a karst area. Even in those locations having no surface expression of karst character, such should be expected in the subsurface.

Q.30. How does the Application address the concerns of karst?

A.30. It doesn't really address them, except to say that no significant impacts are expected, and that a geotechnical investigation will be used to ensure foundation stability.

Q.31. Will grouting cavities under a turbine foundation cause any risks to the environment?

A.31. Yes. From an engineering and stability foundation standpoint only, it may seem desirable to grout open cavities that are found. But it is important to remember that these cavities may actually be an important part of the natural environmental system. They can provide pathways for recharge to the aquifer. If they are grouted there are three potential problems. First, they may block natural recharge to the aquifer, which may cut off the

water supply for area residents. Second, by blocking natural drainage they may reroute water flow, which has to go somewhere, and therefore encourage erosion of sediments in the subsurface in other areas, leading to induced collapses. Third, if new pathways for the movement of surface water into the groundwater system are opened, the underground water supply may become contaminated. Therefore, OPSB should discourage Republic Wind from grouting or otherwise filling openings in the bedrock.

Q.32. Is there any research that describes steps that should be taken to study the risks for siting a wind power project in a particular area?

A.32. A useful resource for this purpose is a paper published in the 13th Sinkhole Conference Proceedings by William J. Bangsund and Kenneth S Johnson, 2013, titled "Evaluating karst risk at proposed wind power projects". Some of the steps that they recommend which do not appear to have been completed or proposed for the Republic Wind Project include a search for relevant literature, survey of local experts, performing site reconnaissance, drilling multiple borings per turbine, use of the downhole camera, and geophysical studies. Republic Wind should be required to take these actions before OPSB acts on its Application in order to find out whether the Project poses an unacceptable risk to the environment. The paper's authors note that "Karst can lead to dramatic tilting and even toppling of a wind turbine. Subtle differential settlement of even 3 centimeters across a 15-meter-wide wind turbine foundation can cause the turbine to be out of tolerance, requiring remedial action". They state that per turbine karst investigation costs maybe $20,000 or more.

Q.33. Do you hold the opinions expressed in this testimony to a reasonable degree of scientific certainty?

A.33. Yes.

Q.34. Does this conclude your direct testimony?

A.34. Yes.

CERTIFICATE OF SERVICE

On October 28, 2019, the docketing division's e-filing system will electronically serve notice of the filing of this document on the following counsel for the parties: Sally W. Bloomfield (sbloomfield@bricker.com), Dylan Borchers (dborchers@bricker.com), Joshua D. Clark (jclark@senecapros.org), Leah F. Curtis (lcurtis@ofbf.org), Chad A. Endsley (cendsley@ofbf.org), Miranda Leppla (mleppla@theoec.org), Amy M. Milam (amilam@ofbf.org), Mark Mulligan (mulligan_mark@co.sandusky.oh.us), Devin D. Parram (dparram@bricker.com), Chris Tavenor (ctavenor@theoec.org), Trent Dougherty (theoec.org), Dane Stinson (dstinson@bricker.com), Derek Devine (dwd@senecapros.org), and Jodi Bair (jodi.bair@ohioattorneygeneral.gov). On the same date, I served a copy of this filing by electronic mail on the above-listed counsel, Dennis Hackenburg at Dennyh7@frontier.com, and Mike and Tiffany Kessler at mkessler7@gmail.com.

/s/ Jack A. Van Kley
Jack A. Van Kley

Summary: Testimony of Ira Sasowsky electronically filed by Mr. Jack A Van Kley on behalf of Local Resident Intervenors